REMARKS:

Abstract:
"The invention relates to" is suppressed according to action.
Minor rewording is provided for clarity.

Specification:
Appropriate corrections are made to the paragraphs of the specification. The word "certain" is a translation informality which is corrected in paragraph [0007] and [0039].

Claim Objections:

Claim 1 is corrected by replacing the transitional phrase "consisting in" by "comprising of".

Claim 1 is further amended to overcome claim 1 rejection under §112 and §103 as will be supported later on.

Claim 1: line 3: "that deexcites" is replaced by "being able of deexciting".
This is because the product taught by the specification is comprised of a sample containing at least one kind of excited isomer nuclides in which at least one said excited isomer nuclide has at least one metastable state (for example 115In49 Spin ½ - see fig. 1), of which the "deexcitation gamma rays" (for example the 336 KeV transition of fig.1) are introduced for further characterisation after the "characterised in" transition.

Note: These "deexcitation gamma rays" shall not be confused with the "excitation gamma rays" used to make the product as taught by the specification.

The rest of the amendment will be supported later on.

Claim rejections – 35 USC §112:

Claims 1-9 are product claims. Claims 2-9 are dependant upon claim 1.
Claim 7 is withdrawn.
Claim 1 is discussed first:
Claim 1 is amended by suppressing the (a) paragraph characterisation because the product is already characterised by the (b) paragraph property of variability of the half life from an initial "variable" half-life strictly lower than the constant half-life of the excited isomer nuclide, this constant half-life thereafter being called the theoretical half-life of the excited isomer nuclide, and the value of the "variable" half-life varying from the value of the initial "variable" half-life to the value of the theoretical half-life, then increasing beyond the value of the theoretical half-life.

As an evidence of the enablement of the specification, an annex with two reductions to practice is provided, which ***describes the measurement of the variable half life of two such "entangled sample" products****:*
Part A describes an "entangled sample" product according to the invention made from Indium excited using the entangled excitation gamma from a Cobalt radioactive source (1173 keV and 1332 keV)(refer to paragraph [0025]).

Part B describes an "entangled sample" product according to the invention made from Indium excited using the entangled excitation gamma produced by the Bremsstrahlung of a particle accelerator (refer to paragraphs [0026] and [0027]. The spectrum is composed of groups of 2, 3 or 4 entangled excitation gamma centred on 1.5 MeV. This second set of measurements is of particular interest because the initial half life has a value of 241 minutes far lower than the constant half life of 268 minutes.

Paragraph [0018] teaches the one skilled in the art that ***the entangled excitation gamma transfer their entanglement to the isomer nuclides****.*
"The radioactive products obtained then, have a variable half life, which is due to the ***coupling*** *between the entangled nuclides."*

The method to obtain the "entangled sample" product requires that one or more irradiation be carried out using entangled gamma according to the teachings of the invention (refer for example to [0024]). While it is taught that groups of gamma are entangled in some arrangements, it is never said that the entanglement of such gamma rays would last 0.5 milliseconds or even longer, because a gamma used for excitation has a very short lifetime from its source to the struck excited isomer nuclide due to the light speed.
The specification clearly points out that the entanglement of the groups of excitation gamma rays is transferred to groups of nuclei of the metastable isomer (refer to the last sentence of [0018]). Because only groups of nuclei are excited to the metastable state of the isomer nuclide and entangled within each group, ***some groups of nuclei may remain entangled over part or whole of the normal half life of such metastable state, or even longer than one normal half life although with a lower probability****.*

Comparison of the set up of Julsgaard et al. versus the product according to the present invention:

In the set up of Julsgaard et al ("Experimental long lived entanglement of two macroscopic objects", Nature, 27 September 2001, Vol.413, Page 400-404) referred here as D5, a series of repeaters work by exchanging entanglement with a gas of atoms that can be excited **collectively** to a metastable state. This excitement is generated by linear **optical** means (column 2, page 400) using a pulsed laser illumination (column 1, paragraph 2, page 401). According to D5, the entanglement is "robust" against the imperfections and provides a "purification" to return to a near-perfect entanglement channels. Stokes beams of light emitted at the front ("forward-scattered Stokes light ") carried in **optical channels** would entangle two repeaters causing interference of these beams.
It should be noted that the device requires optical links between components for an entanglement of repeaters. Since they contain a gas excited collectively, **it is well known that decoherence occurs in less than a millisecond**.
On the other hand, in a more complex protocol presented in Figure 2 on page 402, the implementation of communications is done with, for each transponder, a sets of atoms excited **optically** and **collectively** from their fundamental state |g> to an excited metastable state |e>. The entanglement of optical beams is then sent to these **groups of atoms**. After purification, that is, return to a near-perfect entanglement, it is transferred by the optical beam to the next repeater.

Regarding the gas of atoms used in the transponders of D5, references 20, 21 and 22 of document D5, the atoms used in the **collective entanglement** are Rubidium, Sodium and Caesium. These atoms of the first column of the periodic table of elements include **a single valence electron**, which is the cause of the **optical properties of these atoms.**
For example, for Rubidium, the orbital electrons are in orbits of 2, 8, 18, 8 and 1 electron, and the atomic weight is 85.4678, with an abundance of 72.17% for Rb85 and 27.83% for Rb87.

It should be noted that these two isotopes have **nuclei that have no metastable state**. There are also 6 artificial isotopes of Rubidium with a short lifetime (half-lives of 5 minutes to 32 minutes) that have a metastable state, which is also very short-lived. The same is true for Sodium and Caesium. (Data from CRC Handbook of Chemistry and Physics, 66th edition (1985-1986), CRC Press, Boca Raton, Florida).
In D5, the **collective** excitation is obtained with two (or more) laser beams.
It is therefore clear that in D5, we have **excited optical metastable states** of an **ensemble** of atoms, the excitation concerning the **valence electron** of the atoms.

On the other hand, in the invention described in the present patent application, it is a macroscopic sample containing at least one kind of nuclides isomers of which groups of **a few nuclei of atoms** have been excited to one or more nuclear metastable states by irradiation with **groups of gamma rays** according to the teachings of the patent application. The main isomers nuclides used are listed in Table 1 of the patent application. The irradiation by gamma rays of sufficient energy according to the nuclide isomer, causes an excitation of the metastable nuclei which is unrelated to a collective optical excitation : for example in the case of nuclei of Indium 115, the threshold energy for excitation used in the reduction to practice was in the order of **1080 keV**, this level of energy is not commensurate with the energy of optical photons of laser light that have a wavelength of 300 nm (or **4.13 eV**) to 800 nm (or **1.55 eV**). The “entangled sample” product obtained by the present invention is therefore of a totally different nature as it has the **property of a long lasting entanglement of some groups of nuclei of the metastable isomer nuclides**.

Claim 1: The unsupported wording of the limitation “the table of isotopes” in part b line 7 is suppressed and replaced by the phrase “the constant half life of the corresponding normal metastable isomer nuclides” as it is a well known terminology to the one skilled in the art, such constant half life being given in table I or in the cited “Table of Isotopes, CD-ROM, 8th edition, Version 1.0, Richard B. Firestone, Laurence Berkeley National Laboratory, University of California” or in similar tables of isotopes.

Claim 10: The claim structure has been simplified by removing the referral to claim 1 and the introduction, which was redundant with information supplied in the characterising part.
In order to comply with MPEP §2173-05(d), the claim is limited to the main teaching while the various sub-cases detailed in the specification are moved in new dependant claims 20, 21, 22, 23 and 24. In the phrase “at least certain groups of entangled gamma rays”, the word “certain” is a translation informality which has been corrected to “some”. The teaching of claim 10 has support in paragraph [0018] and [0024].

Claim 20 further characterises the details of the transfer of the entanglement of gamma rays to nuclei of the excited isomer nuclide.
The teaching of claim 20 has support in paragraph [0018].
Claim 21 specifies the sub-case of entangled gamma rays emitted in a cascade from a radioactive source.
The teaching of claim 21 has support in paragraph [0025].
Claim 22 specifies the sub-case of entangled gamma rays produced by the Bremsstrahlung of accelerated particles.
The teaching of claim 22 has support in paragraph [0026] and [0027]).
Claim 23 specifies a mode of the Bremsstrahlung sub-case where the particles are electrons.
The teaching of claim 23 has support in paragraph [0026] and [0027]).
Claim 24 specifies a mode of the Bremsstrahlung sub-case where the particles are alpha particles, or protons.
The teaching of claim 24 has support in paragraph [0024].

Claim 11 is updated because the absence of reference to claim 1 requires that the variable half-life of the excited isomer nuclide obtained thru the method of claim 10 be introduced in order to maintain the further characterisation of the initial "variable" half-life, which varies varying with the duration of the irradiation and / or with the power of the irradiation. Claim 11 is a manufacturing process for homogeneity with claim 10.

Claim 12-17 are amended to reflect the physical activities to be applied when exercising the method to make the corresponding uses.

Non-obviousness: Claim Rejections – 35 USC § 103:
*The **set-up** taught by Vysotskii is a **not a distinct product in itself capable of producing deexcitation gamma rays with a variable half-life on its own**.*
In Vysotskii, in order to produce a higher "fixed" half-life than the constant half life of the metastable state, the product has to be maintained in the set up.

Vysotskii's first set up :
A source compound comprising excited Sb119m (11/2-), with a very short half life of 18.5 nanosecond, is maintained close to a screen made of stable Sb.
The Mossbauer effect occurs because the screen is made of stable atoms identical to the source excited metastable nuclide and because the transition from Sn119m (11/2-) to Sb emits a 23.8 KeV gamma having the required properties to be absorbed by a stable Sb atom of the screen and then be back scattered to the source as a gamma ray of same energy (negligible recoil from the screen).

Vysotskii's second set up :
A source of Co produces excited Fe57m (3/2-), with a very short half life of 98.1 nanosecond. It is maintained within a cylindrical screen made of stable Fe57.
The Mossbauer effect occurs because the screen is made of stable atoms identical to the source excited metastable nuclide and because the transition from Fe57m (3/2-) to Fe57 emits a 14.4 KeV gamma having the required properties to be absorbed by a stable Fe atom of the screen and then be back scattered to the source as a gamma ray of same energy (negligible recoil from the screen).

The underlying Mossbauer effect:
In Vysotskii, the two set-up use screens of the same types of atoms as those contained in the source, but in their ground states. The deexcitation gamma emitted by the source shall have a very narrow spectrum (implying a very short half life) in order for the Mossbauer effect to take place in the screen: due to the fact that the atoms within the screen are recoil-less (very low temperature), an incident gamma has a probability of being scattered back with exactly the same energy. If such a gamma encounters the source, one nucleus at most has a chance to be re-excited by resonance, thus lowering the decreasing rate of the metastable level population, and consequently increasing its apparent half life time.
The Mossbauer resonance involve the interaction between one single gamma ray from the source and one nucleus of the stable atom of the same isomer nuclide within the screen. The back scattered gamma rays are not entangled between themselves because each involved nucleus of the screen absorbs one gamma ray and remit one gamma ray when the resonance is achieved.
The resulting property of fixed half life higher than the constant half life of the isomer nuclide is not encountered on a stand alone product, but a property of a fixed half life higher than the constant half life is obtained as the result of a ***continuous*** *interaction with a screen within a set-up under very specific conditions. Refer to Vysotskii, page 212 – first alinea of paragraph 2 continued on page 1313: "during action of resonant screen".*
In fact, should the excited isomer nuclide be removed from the Vysotskii set-up it is most likely to recover instantaneously the constant half life characterizing the involved metastable state.

Cheon "The modified decay width of the radioactive nucleus" is a document from 2007, which has been published in 2007. It is opposed in the action in an attempt to induce that the Vysotskii set-up would have produced entangled metastable nuclei, or more precisely that it would provide proof that that Vysotskii's set-up would have described inherently the "entangled sample" product of this patent application.

The Cheon set-up:
A source compound comprising excited Sb121m (7/2+) is maintained close to a metal shield made of Au or Pt.
Very low temperature is to be maintained.
Sb121m (7/2+) has a constant half life of 3.46 nanoseconds and emit one single gamma ray of 37.13 KeV when returning to the stable Sb121.

Cheon uses an Au or Pt screen, which ***do not produce the Mossbauer effect****, which requires the same atoms in the shield and in the source.*

Furthermore the phenomenon behind Cheon's Au or Pt shield for a source of Sb involves the conduction electrons of the metallic shield to scatter back some of the gamma emitted by the source. The 37.13 keV emitted by the source are not entangled since one gamma is emitted by one excited metastable nucleus of the source. Such a gamma is scattered by the Au or Pt shield in a ***Compton process****, the output of which can be* ***no more*** *than a single gamma of the same energy: in fact one or several conduction electrons of the shield are energetised and, when coming back to the conduction band, they can emit:*

- *either **one single gamma of same energy**,*
- *or **one or several gamma of lower energies**, the sum of which is lower or equal than the incoming gamma's energy.*

If a single gamma of same energy has been emitted, it is not entangled and, should it be directed back to the source, it may re-excite one nucleus in the source thus lowering the decreasing rate of the metastable level population, and consequently increasing its apparent half life time.
*On the other hand if several gamma of **lower energies** are emitted by a single electrons, they might be entangled, **but anyhow would be unable to re-excite nuclei of the source**. **Thus there are no entangled metastable nuclei produced within the source in the Cheon's set up**.*

Hence there are three reasons why the inherence assumption cannot hold:

- *Firstly the Cheon set-up by using the **Compton effect** does not produce entangled metastable nuclei within the source.*
- *Secondly Vysotskii's set-up by using the **Mossbauer effect** does not produce entangled metastable nuclei within the source.*
- *Thirdly the effect occurring in the Cheon set-up **does not account for** the effect occurring in the Vysotskii set-up*

Neither Vysotskii, nor Cheon taught that an isomer nuclide excited to a metastable state under given conditions could lead to a product having a variable half life on its own.

It is very unlikely that the one skilled in the art would have been able to obtain an excited isomer nuclide to a metastable state having a variable half life of deexcitation gamma rays on its own, as the routine execution of the set-up of Vysotskii, even with variations, is just applying the Mossbauer effect. The Mossbauer effect implies the use of a set-up including a particular screen and extremely low temperature.
*In the Vysotskii set-up a reflected gamma excite the nuclei of the ground state level back to the first metastable level, thus increasing the half-life above the constant half life of the metastable isomer nuclide, while maintaining it within the set-up. Hence the one skilled in the art while producing variations of the Vysotskii set-up **would never encounter a decreasing half-life compared to the constant half life of the first metastable state**.*

Furthermore it has never been reported that after a source had been used in a Vysotskii's set-up, and the screen has been removed, then the half life of the source measured on its own would have been variable.

The Vysotskii and the Cheon set-up are intended for lowering the probability of deexcitation gamma rays, which is the opposite of the initial behaviour of the "entangled sample" product according to the invention.

In view of the documents, we propose to amend claim 1 in order to characterise the "entangled sample" product by its variable half life property as taught within the description.

We would also like to introduce the new claim 19 (dependant upon amended claim 1) in order to maintain a claim to the structural property of the product, namely that it is

additionally "characterized in that groups of two or several excited nuclei of the aforesaid excited isomer nuclides of the aforesaid sample, are entangled between them and presenting quantum coupling between some of the excited nuclei of the aforesaid excited isomer nuclides".
In fact claim 19 is nearly equivalent to the former claim 1 which have been examined in the action and answered above.

Claims 2 to 9 are dependant upon claim 1, the product of which is not taught by Vysotskii. Hence claims 2 to 9 which encompass the characteristics of the product of claim 1 and additional characteristics not suppressing any characteristic from claim 1, are non obvious.

Claim 10:
As has been discussed under claim 1, the Vysotskii set-up does not produce entangled gamma rays because the Mossbauer resonance produces with a probability at most one gamma ray of same energy back to the source for one gamma ray from the source which has excited a stable nucleus of same type as of the isomer nuclide of the source.

As has been discussed under claim 1, Cheon set-up does not produces entangled gamma thru the Compton effect relied upon, nor does it change the nature of the Mossbauer effect on which the Vysotskii set-up relies.

Neither the Vysotskii set-up nor the Cheon set-up employs or produces entangled gamma rays capable of exciting the source isomer nuclide.

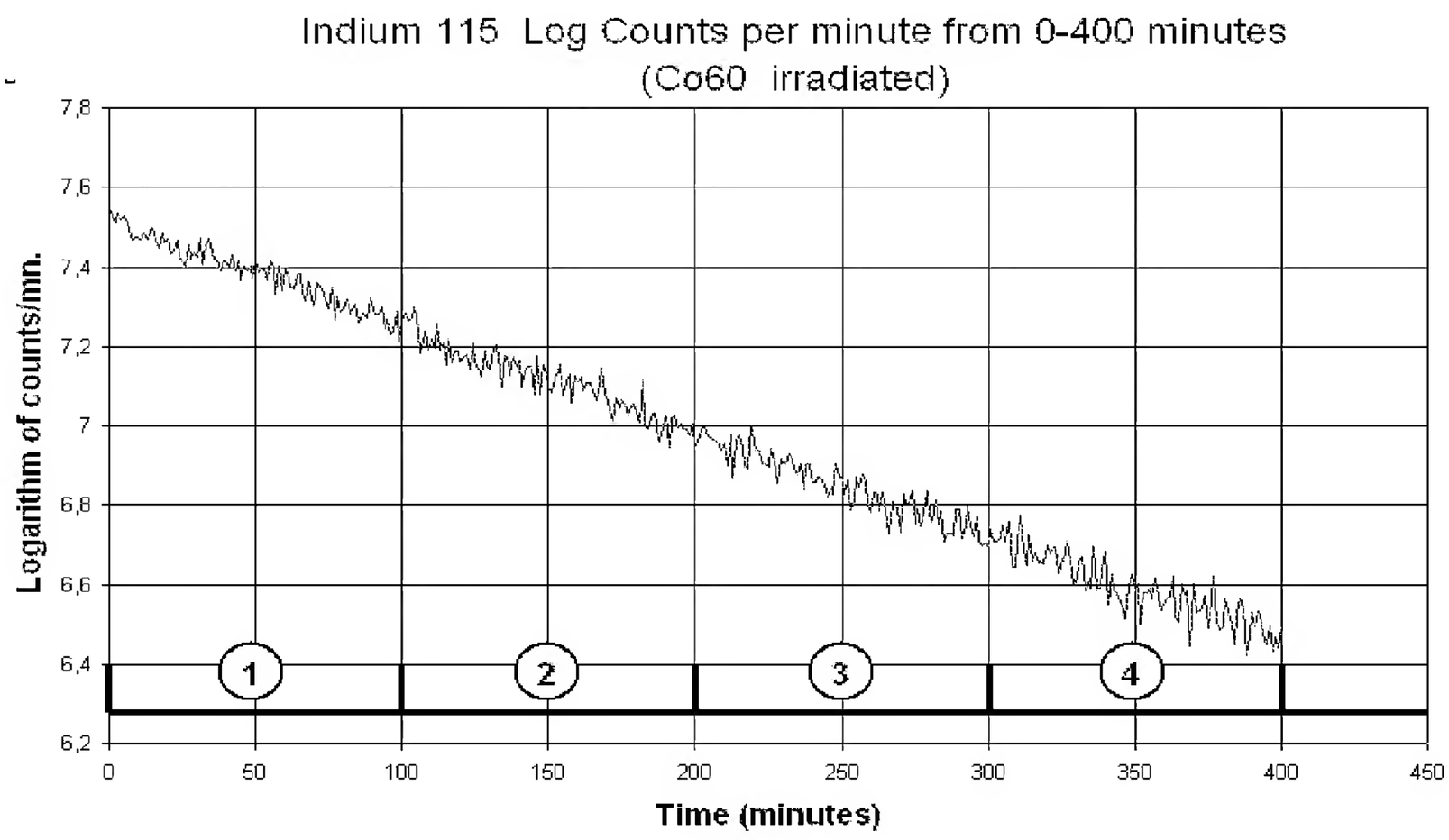
Hence claim 10 method is not obvious to the one skilled in the art when considering Vysotskii's set-ups and the common knowledge at the priority date.

Annex.

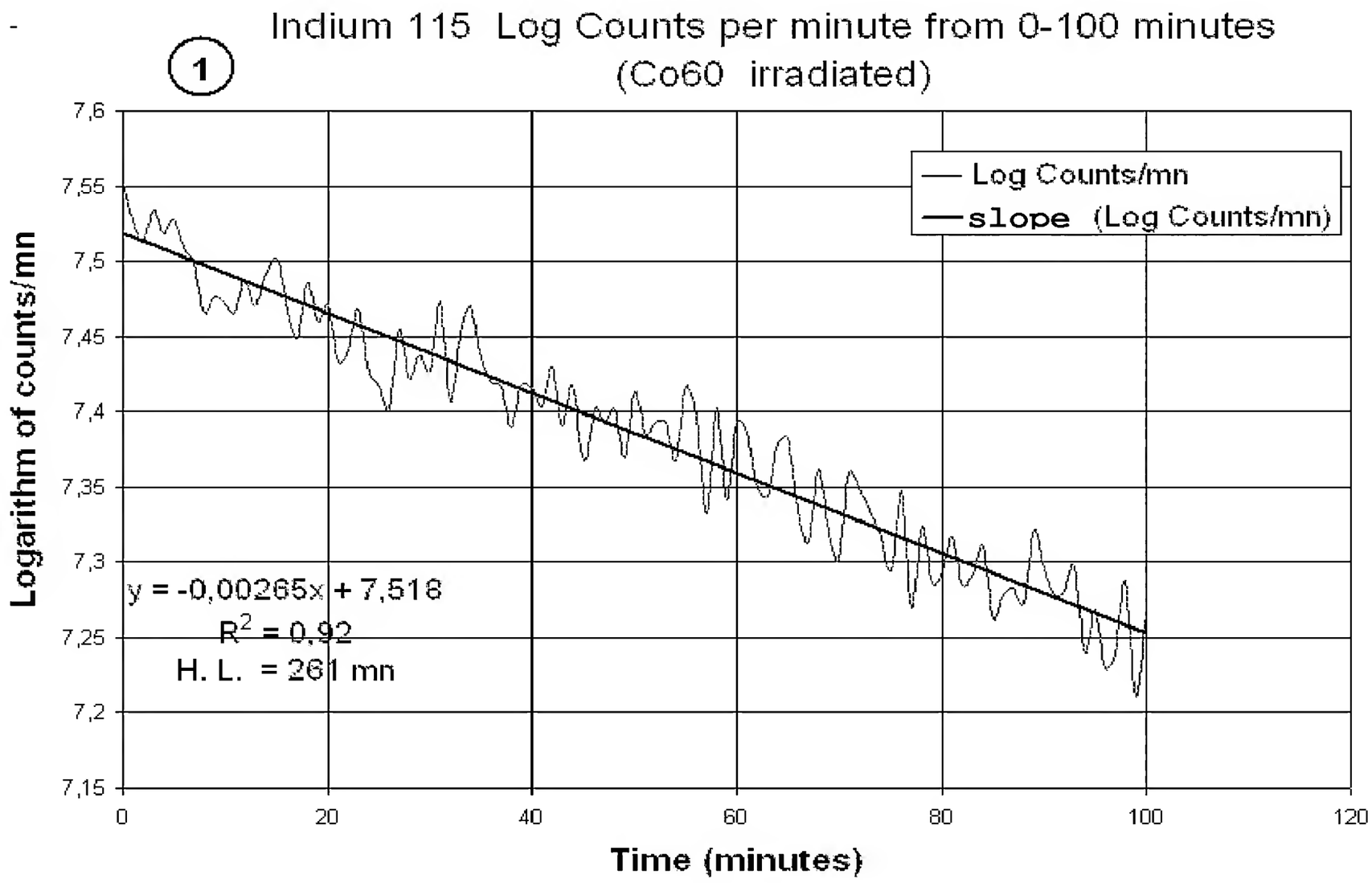
Part 1: Co60 irradiation and Part 2: CLINAC Irradiation

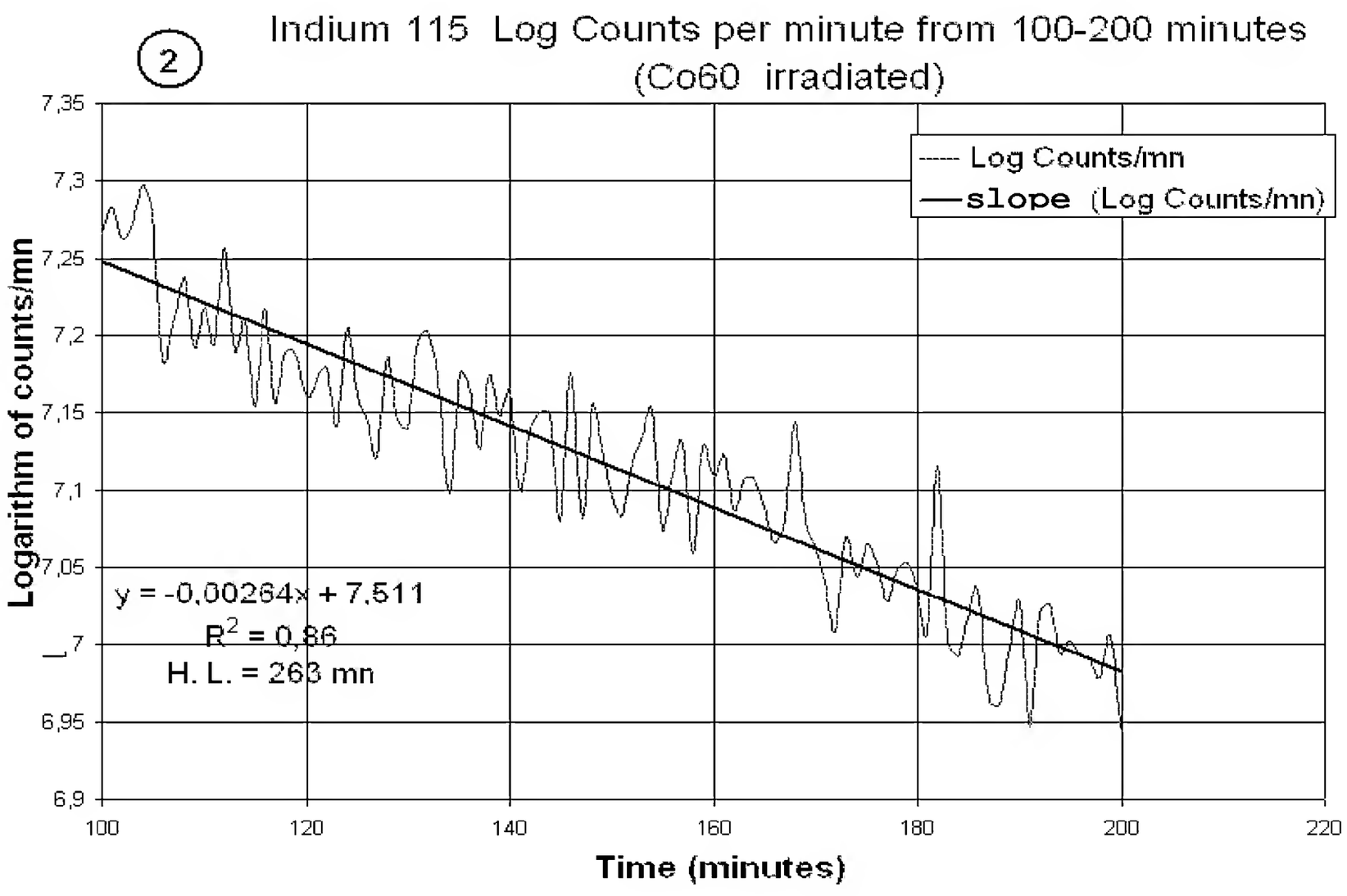
Part 1: Experimental Reduction to Practice, Co60 Irradiation USPTO Patent application US01

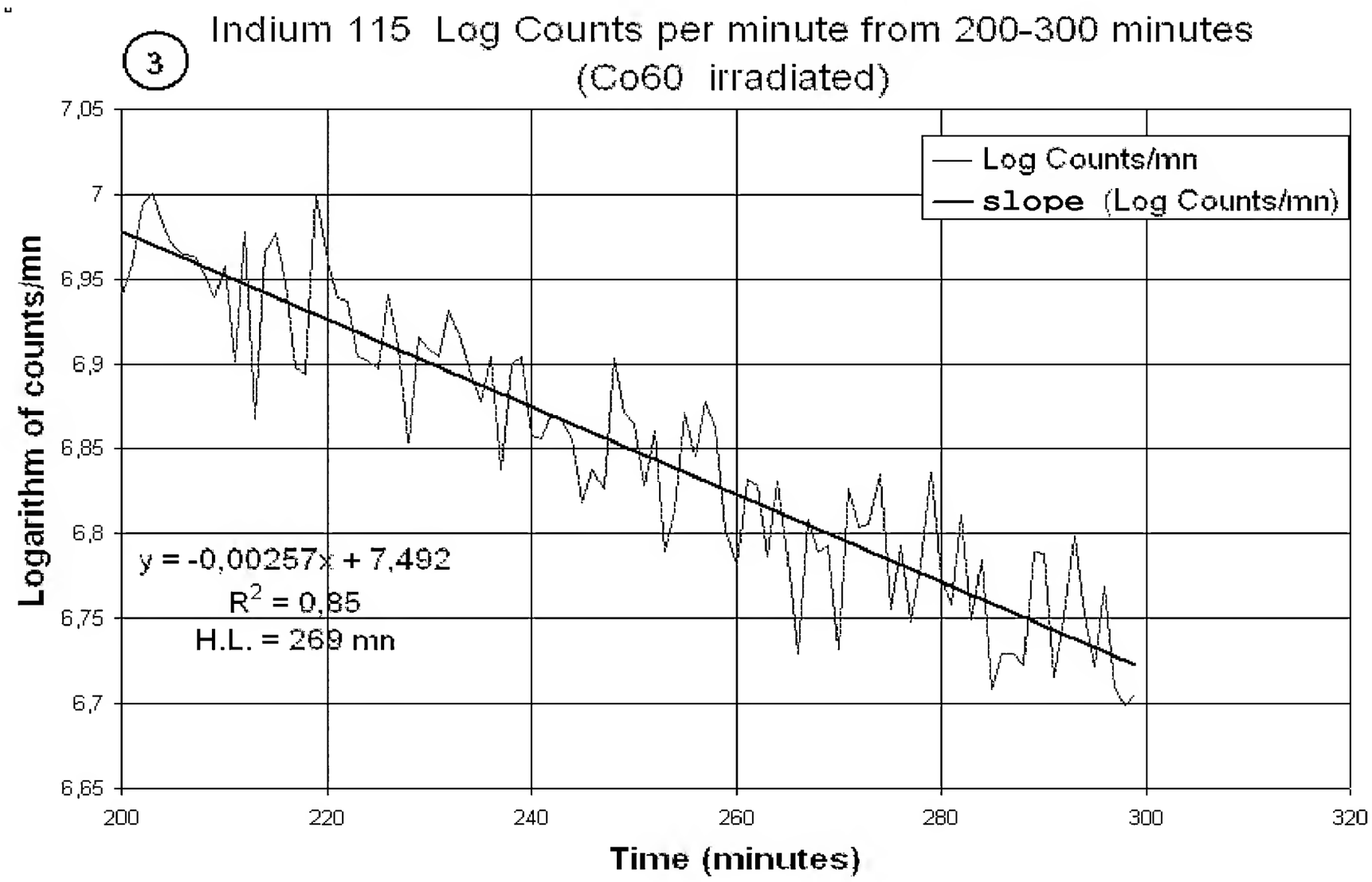
The Indium 115 samples used in the experiments were:
25 mm wide, 75 mm long, 0.3 mm thick.
The abundance of In 115 was 95.72%, purity 99.99%.
The irradiator was a HICS Shepherd upright irradiator with two 1500 Ci sources (at the time). The samples were taped about 25 mm away from the sources.
The time of irradiation was 12 hours for 95% saturation.
The following graph is the recording of the counts per minute emitted at 336 keV by the excited isomer nuclide: Indium 115^{m}.

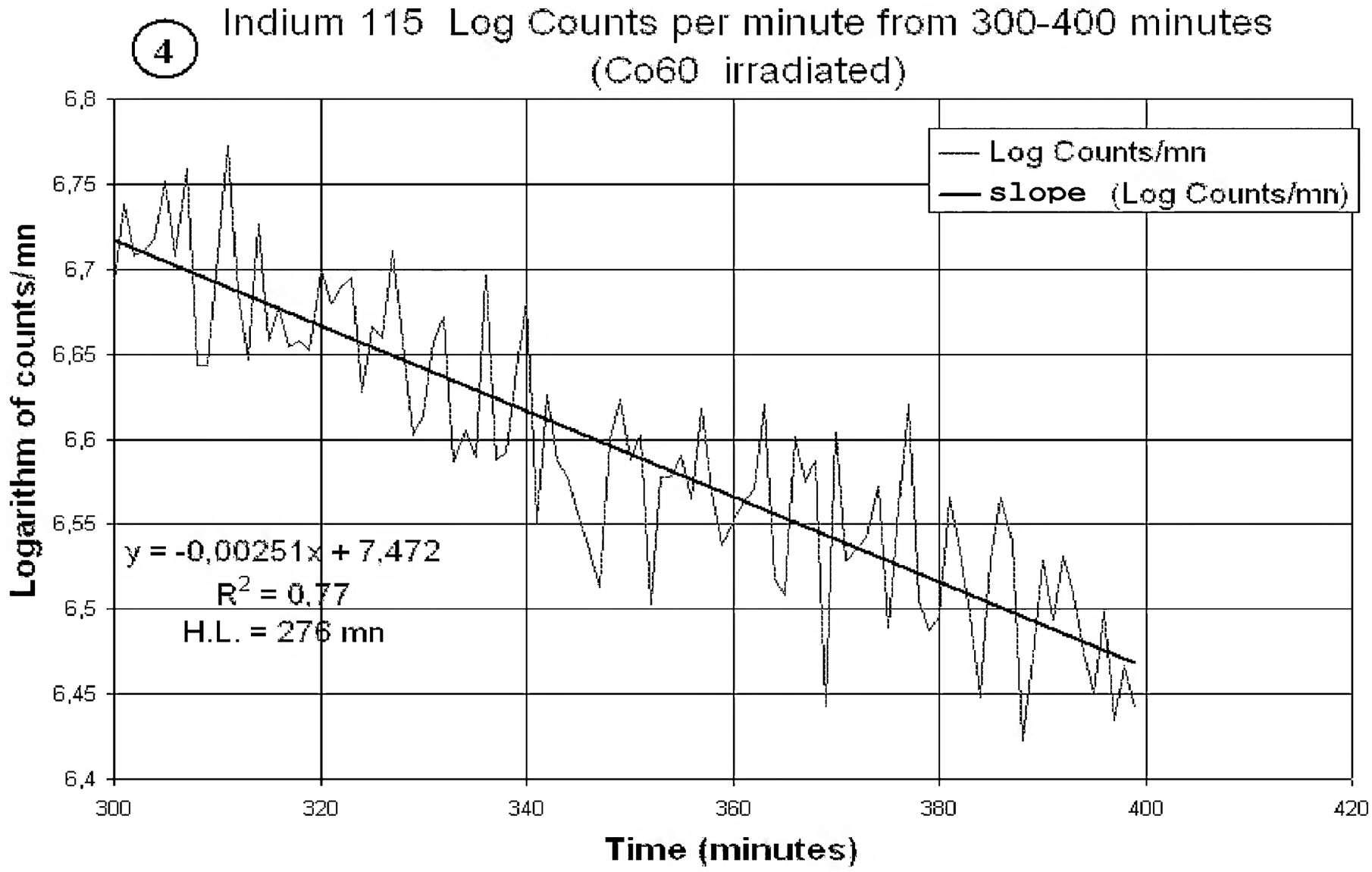


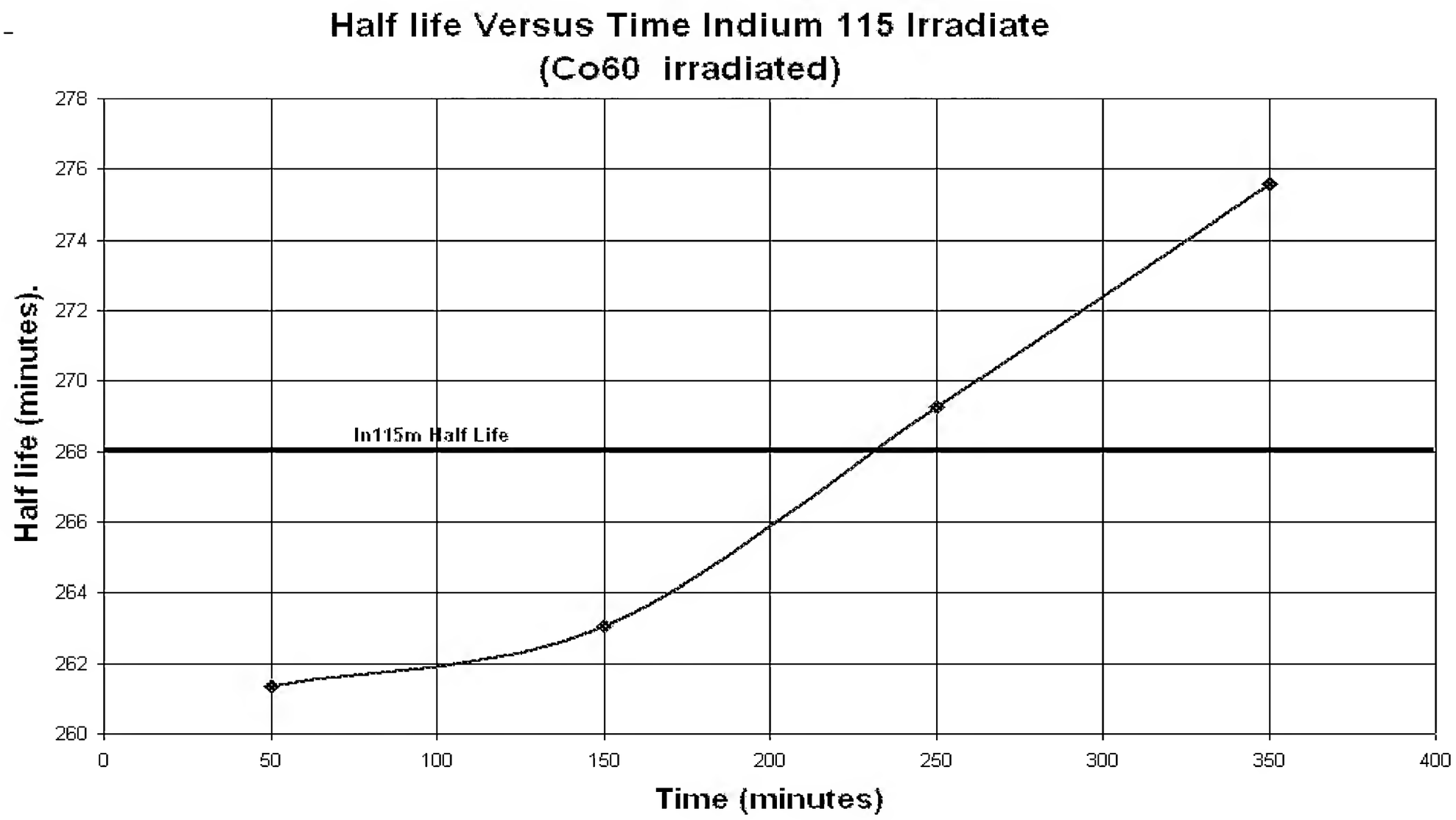
The variable half-life is computed over intervals of 100 minutes:
The following graphs display the logarithm of the deexcitation gamma rays counts per minutes of the "entangled sample" product. A linear regression equation is used to compute the slope and the regression coefficient (R^2). The variable half-life (H.L.) is noted λ and the slope is noted P (probability of deexcitation per minute) in the equation of paragraph [0002] which are all well known to the one skilled in the art.


Indium 115 Log Counts per minute from 0-100 minutes
(Co60 irradiated)
1
Log Counts/mn
slope (Log Counts/mn)
y = -0,00265x + 7,518
R2 = 0,92
H. L. = 261 mn
Logarithm of counts/mn
Time (minutes)


Indium 115 Log Counts per minute from 100-200 minutes
(Co60 irradiated)
2
Log Counts/mn
slope (Log Counts/mn)
y = -0,00264x + 7,511
R2 = 0,86
H. L. = 263 mn
Logarithm of counts/mn
Time (minutes)

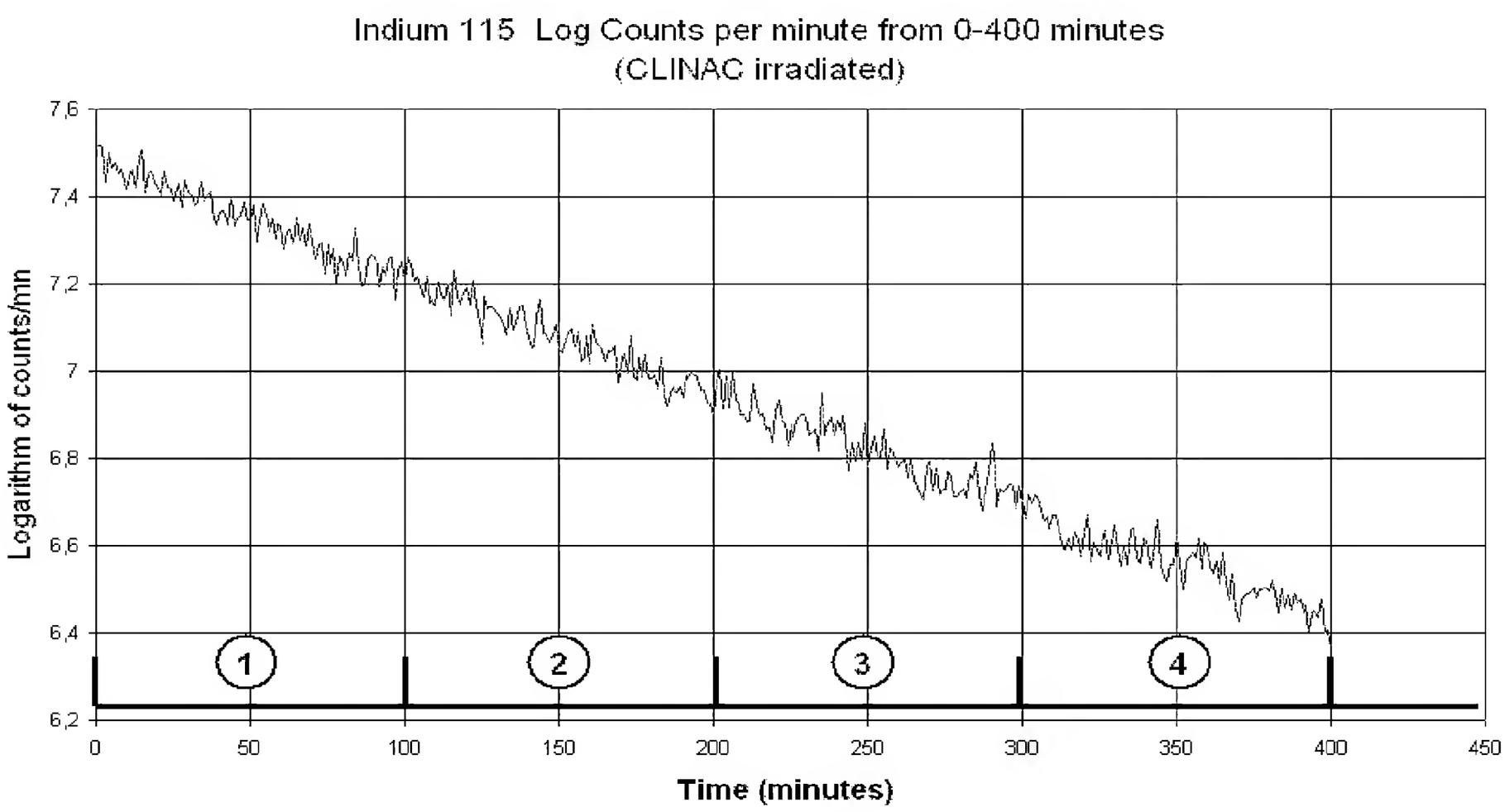

3
Indium 115 Log Counts per minute from 200-300 minutes
(Co60 irradiated)
Log Counts/mn
slope (Log Counts/mn)
y = -0,00257x + 7,492
R2 = 0,85
H.L. = 269 mn
Logarithm of counts/mn
Time (minutes)
7,05
7
6,95
6,9
6,85
6,8
6,75
6,7
6,65
200
220
240
260
280
300
320


4
Indium 115 Log Counts per minute from 300-400 minutes
(Co60 irradiated)
Log Counts/mn
slope (Log Counts/mn)
y = -0,00251x + 7,472
R2 = 0,77
H.L. = 276 mn
Logarithm of counts/mn
Time (minutes)
6,8
6,75
6,7
6,65
6,6
6,55
6,5
6,45
6,4
300
320
340
360
380
400
420

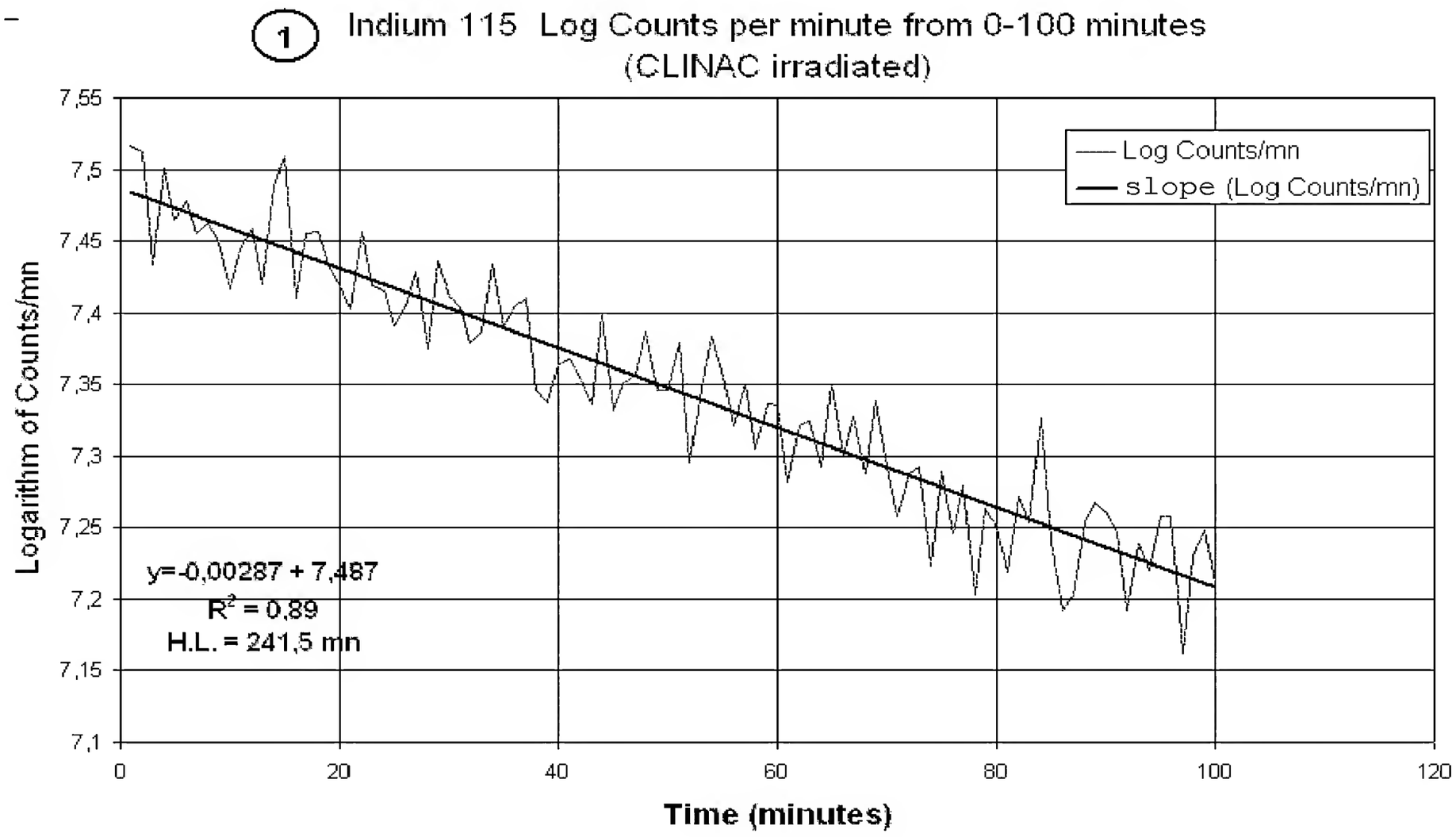

Half life Versus Time Indium 115 Irradiate
(Co60 irradiated)
Half life (minutes).
Time (minutes)
In115m Half Life
278
276
274
272
270
268
266
264
262
260
0
50
100
150
200
250
300
350
400

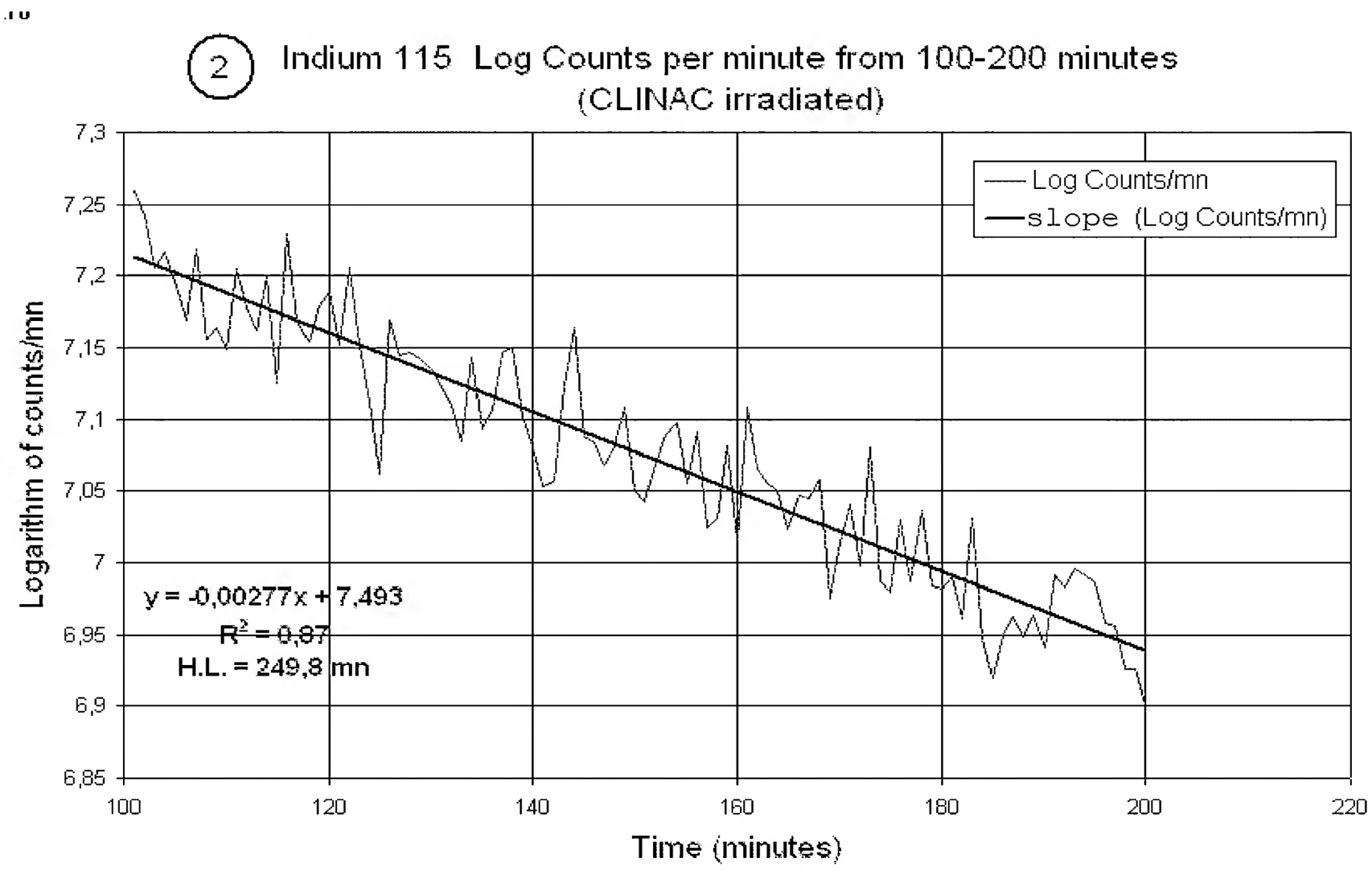
Part 2: Experimental Reduction to Practice, CLINAC irradiation USPTO Patent application US01

The Indium 115 samples used in the experiments were:
25 mm wide, 75 mm long, 0.3 mm thick.
The abundance of In 115 was 95.72%, purity 99.99%.
The CLINAC accelerator was a medical type instrument.
The samples were irradiated to 20 Gray at the rate of 0.01 Gray per second during several lapses of time.
The gamma head of CLINAC was located one meter above the table on which the samples were led.
The beam was collimated in such a way that the field was the size of our samples.
The following graph is the recording of the counts per minute emitted at 336 keV by the excited isomer nuclide: Indium 115^{m}.

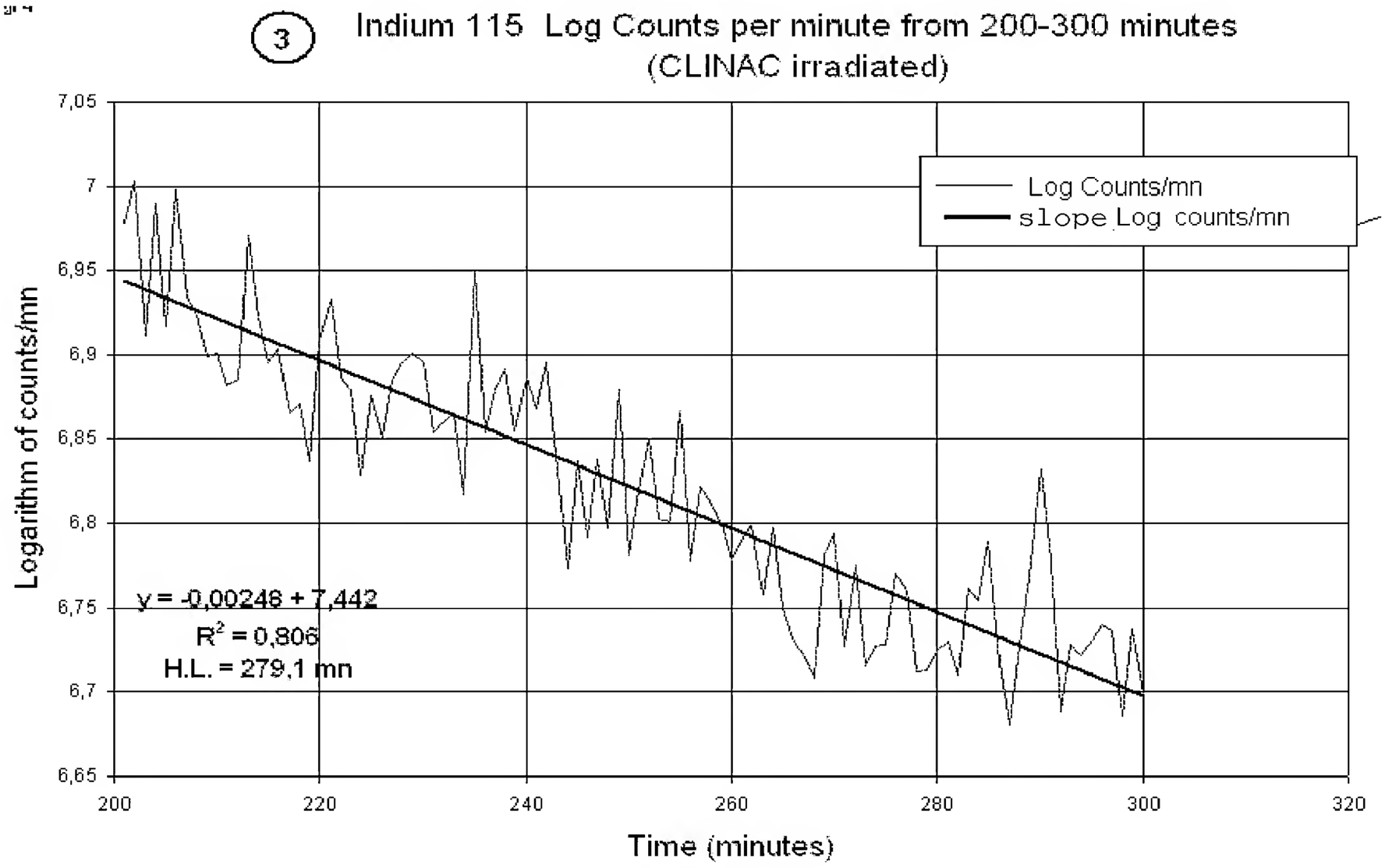


The variable half-life is computed over intervals of 100 minutes:
The following graphs display the logarithm of the deexcitation gamma rays counts per minutes of the "entangled sample" product. A linear regression equation is used to compute the slope and the regression coefficient (R^2). The variable half-life (H.L.) is noted λ and the slope is noted P (probability of deexcitation per minute) in the equation of paragraph [0002] which are all well known to the one skilled in the art.

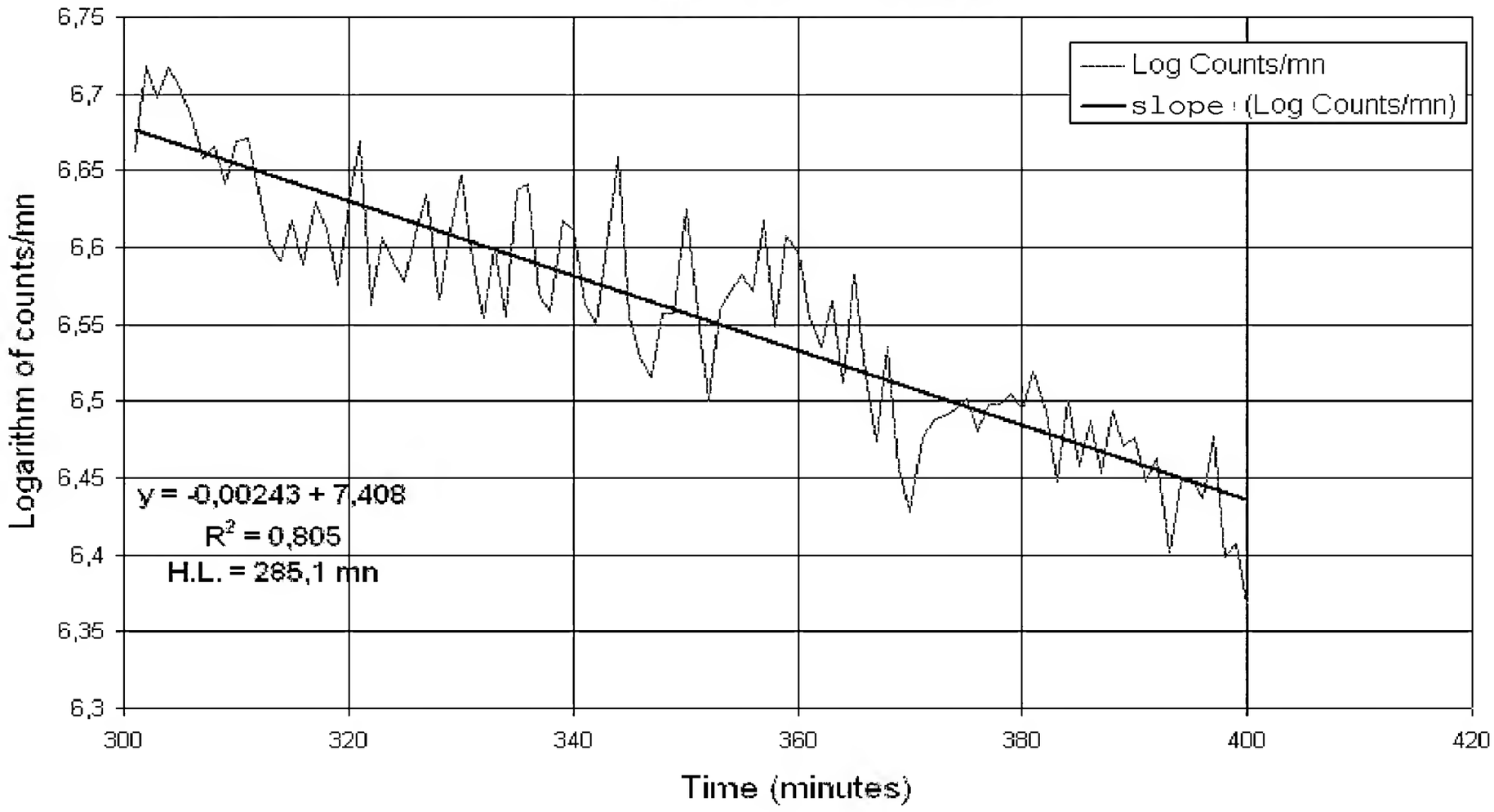

1
Indium 115 Log Counts per minute from 0-100 minutes
(CLINAC irradiated)
Log Counts/mn
slope (Log Counts/mn)
Logarithm of Counts/mn
y=-0,00287 + 7,487
R² = 0,89
H.L. = 241,5 mn
Time (minutes)

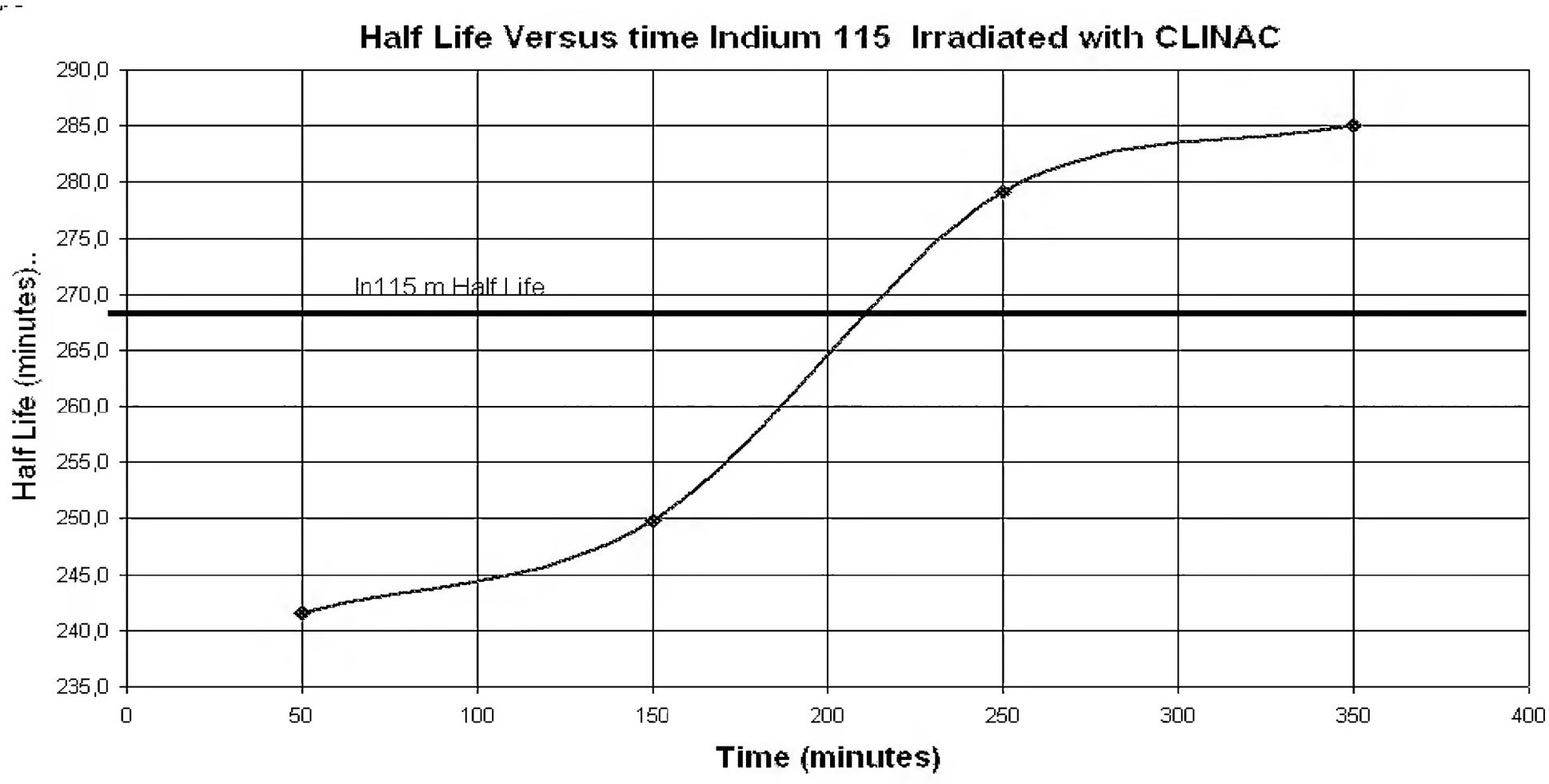

2
Indium 115 Log Counts per minute from 100-200 minutes
(CLINAC irradiated)
Log Counts/mn
slope (Log Counts/mn)
Logarithm of counts/mn
y = -0,00277x + 7,493
R² = 0,87
H.L. = 249,8 mn
Time (minutes)

3 Indium 115 Log Counts per minute from 200-300 minutes
(CLINAC irradiated)



4 Indium 115 Log Counts per minute from 300-400 minutes
(CLINAC irradiated)




Half Life Versus time Indium 115 Irradiated with CLINAC
290,0
285,0
280,0
275,0
270,0
265,0
260,0
255,0
250,0
245,0
240,0
235,0
In115 m Half Life
Half Life (minutes)..
0
50
100
150
200
250
300
350
400
Time (minutes)